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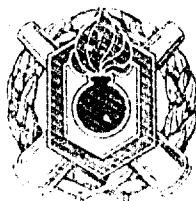
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RAAM INTEGRATED CIRCUIT SOURCE CHANGE ANALYSIS

John Printz

September 1990

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INTRODUCTION

In the middle 1970's, Honeywell Defense Systems Group proposed to the Government the concept of the Family of Scatterable Mines (FASCAM). These mines were to be electronically controlled using state-of-the-art technology for that time. The electronic components consisted of both off-the-shelf components (resistors, capacitors) and custom components (digital and analog integrated circuits) which were technologically feasible at the time.

The FASCAM mines were designed to be lethal only for a specified period of time. That is, the mines are armed upon delivery from the particular delivery system in question. These delivery systems include 155-mm artillery rounds, ground-vehicle mine dispensers, high-performance aircraft mine dispensers, and hand emplacement. Upon enablement of the electronics inside of the mines, these mines are lethal and fully operational for a specified period of time. Upon reaching this specified period of time, the mines will self-destruct to render the minefield sterile and relieve the Corps of Engineers of having to retrieve the mines. This time depends upon the mines being deployed; that is, each mine has its own specific self-destruct times.

One such FASCAM mine is the Remote Anti-Armor Mine (RAAM, M718/M741, fig. 1). This mine is an artillery delivered antitank mine which uses electronic circuitry to control the operation of the mine (fig. 2). Nine RAAM mines are loaded into an M483A1 artillery shell for battlefield delivery (ref 1). The two primary functioning sequences of the RAAM mine are timing and target sensing, both of which have digital integrated circuits as the primary electronic devices.

For fiscal year (FY) 1988 and 1989, Accudyne Corporation of Janesville, WI was awarded the production contract on the RAAM program. Recognizing the increasing difficulty in obtaining production parts to meet the technical data package (TDP) configuration, Accudyne proposed changing the TDP to allow for a more current technology to be used on the RAAM program. In particular, Accudyne proposed changing from gold eutectic die attach I.C. as specified in the TDP to silver-glass die attach I.C. from Motorola (table 1).

RAAM ELECTRONIC LENS ASSEMBLY DESCRIPTION

Overview

The RAAM mine was designed to have its operation controlled electronically. To accomplish this, an electronic lens assembly (ELA) was incorporated into the mine housing. The ELA consists of digital and analog integrated circuits and active and

passive discrete components mounted onto a printed wiring board (PWB). Due to the gun-launched environment of the RAAM mine, the entire PWB is encapsulated into potting material.

For the RAAM mine, the ELA becomes functional upon ejection from the 155-mm projectile. At this time, the mine recognizes the setback forces and spin from the projectile. This causes the system batteries to become functional and the firing capacitor shorting bar to be destroyed, rendering the electronic circuitry active. The electronic sensors in the mine will then be in an "idle" condition until the mine has come to rest on the ground. Then, the electronic sensors will become active, and the mine will be fully armed.

The primary mine functioning system is composed of a timing function sequence and a target sensing function sequence. The possible mine functioning modes and their sources are listed in figure 3. For the timing functioning sequence, its primary electronic device is the timer I.C. Similarly, the target sensing functioning sequence has both the timer I.C. and the target sensor I.C. as its primary electronic devices.

Timing Functioning Sequence

The timing functioning sequence (timer) provides timing and control to the RAAM ELA. Contained in the timer are a primary time base (PTB) or system clock for the electronics and a test time base (TTB) to verify the timing of the PTB. If the PTB is clocking too slowly, a barrier circuit will detonate the mine automatically. Also, the timer uses the PTB in a self-destruct (SD) circuit that detonates the mine after a prescribed time limit (the M741 is the regular SD time RAAM; the M718 is the extended SD time RAAM). A low voltage detect (LVD) circuit is incorporated into the timer. The LVD circuit detonates the mine if the battery voltage drops to a point where the mine will not function properly if the voltage drop continues. Finally, the timer provides a firing signal to the mine's explosive train from either the target sensor or an antidisturbance (AD) switch (if the mine is so equipped; that is, not every RAAM mine is equipped with an AD switch).

The timer circuitry of a timer I.C. and several resistors, transistors, and capacitors external to the I.C. The timer I.C. (fig. 4), when originally designed, used single complementary metal oxide semiconductor (CMOS) technology in a digital format. The original packaging of the timer I.C. is a 16-pin dual in-line package (DIP) with a gold eutectic die attach (fig. 5).

Target Sensing Functioning Sequence

The target sensing functioning sequence (target sensor) detects the presence of an armored vehicle (tank) by recognizing the vehicle's particular magnetic target signature. When a vehicle with the proper magnetic target signature passes over the mine, the sensor detects the correct change in the intrinsic magnetic field and sends a firing signal to the timer.

The target sensor is functional a short time after the mines leave the shell. This allows enough time for the mines to fall to the ground and become physically stable. The target sensor will remain active during the entire lethal time of the mines in question (remember that the M718 has a different lethal time than the M741).

The target sensor circuitry consists of a target sensor I.C. (fig. 6), a triple op-amp, and other various electronic components (both discrete components and components in DIP). As was the case with the timer I.C., the target sensor I.C. used single CMOS in a digital format in a 16-pin DP with gold eutectic die attach (fig. 7) when the ELA was originally designed and when the contracts were awarded to Accudyne.

RECENT CONTRACT HISTORY

RAAM Development

The RAAM mine system was originally designed by Honeywell Defense Systems Group. Honeywell was also the contractor during initial production and full production states of the program. However, other contractors have been awarded contracts in recent years to produce the RAAM ELA.

Current RAAM ELA Contractor

For the FY 1988 and FY 1989 solicitations on the RAAM program, Accudyne Corporation of Janesville, WI was awarded production contracts for RAAM ELA. The quantities* of the ELA to be delivered to the Iowa Army Assembly Plant (IAAP) for assembly into mine housings imply that a profitable production process should be employed.

*FY89 - 394, 574 lenses; FY89 - 86, 572 lenses.

Accudyne's Proposed Timer I.C. and Target Sensor I.C. Source

In Accudyne's search for sources of timer and target sensor I.C., some difficulty (both economic and technical) was encountered in finding manufacturers that could provide I.C. that fulfilled the TDP requirements. Also, the Government implemented a policy that required all major components of electronic systems must be manufactured "on shore;" that is, these components must be manufactured in the United States or Canada. The policy is to be in effect for all contract solicitations starting in FY 1989.

With the above restrictions imposed upon RAAM I.C. suppliers, Accudyne determined that the only cost-effective supplier of the timer and target sensor I.C. was Motorola. Motorola had the capability to produce these I.C. both in the United States (Arizona) and in the Far East (Malaysia). However, Motorola had recently converted its production facility for all commercial I.C. and most military I.C. to incorporate the use of silver-glass die attach. The RAAM TDP specified that the I.C. must incorporate a gold eutectic die attach; therefore, Accudyne had to submit a formal engineering change proposal (ECP) and present all supporting documentation and test results for the change to be approved. Also, if the change was to involve a substantial savings to both Accudyne and the Government, the financial documentation for the evaluation of a value engineering change proposal (VECP) must also be submitted. However, Accudyne did not encounter any cost savings with this change due to the Government test plan that was required of Accudyne and Motorola.

DIE ATTACH PROCESSES

General Definition

A die attach process is simply a means by which a transistor die is bonded into the DIP. The transistor die is placed inside the DIP on a layer of die attach material. The packaged is then heated to activate the attaching material and remove any impurities. After being allowed to cool, electrical leads are then connected from the attached transistor die to the pins of the DIP. Finally, the cover to the DIP is attached in place to complete the packaging.

Gold Eutectic Die Attach

The original die attach process used for the RAAM timer and target sensor I.C. is known as a gold eutectic die attach process. This method was the industry standard (both commercial and military) at the time when the RAAM TDP was established.

In this process, the transistor die is placed into the DIP on top of a small area of a gold-based composite (organic solvents are present in the composite to allow for adequate die placement). The die is then moved around the gold composite to ensure that

the die attach material has made sufficient contact with the transistor die. Then, the package is heated to both remove the organic solvents and to melt the gold for die attachment. Upon cooling, the lead wires are connected between the transistor die and the pins of the DIP and the entire package is sealed with hermetic seal. During a hermetic seal process, the DIP is evacuated of as much air and water vapor as possible (ideally, all air and water vapor would be evacuated) and the DIP is then sealed. This is necessary to provide an inert environment for the transistors to operate.

Silver-glass Die Attach

Motorola's proposed die attach for the RAAM timer and target sensor I.C. uses a silver-glass die attach. This process is, at this time, an industry standard to which many I.C. manufacturers are converting.

In this process, a controlled quantity of a silver-glass paste (containing silver metal, glass particles, and organic solvents that allow for injection into the DIP) is dispensed onto the DIP. Then, the transistor is placed into the silver-glass paste. The DIP is then heated to remove the organic solvents and to activate the bonding action of the silver and the glass. Finally, the DIP is subjected to a hermetic seal process as described above. As in the case with the gold eutectic die attach process, lead wires are bonded from the transistor die to the pins of the DIP and the package is hermetically sealed upon cooling.

Gold Eutectic Die Attach Versus Silver-glass Die Attach

For many years, the industry standard for die attachment was gold eutectic die attach. The reason this process was initially used resulted from the metallurgical properties of gold. The metal was flexible to absorb the mechanical stresses incurred in the DIP. Also, the flexibility of gold and its relatively low melting point allowed for an easy application into the DIP.

The primary reason for the switch to silver-glass die attachment is cost. With the increases in the price of gold in recent years, a switch to another die attach process using another material appeared to be logical.

The major difference between gold eutectic die attachment and silver-glass die attachment is the flexibility of the die attach material. Both the silver metal and the glass used in the silver-glass die attach process are much more rigid than gold. As was stated earlier, the RAAM mines are deployed ballistically; therefore, there existed a concern as to whether the silver-glass die attach process could be applicable for this particular application.

GOVERNMENT TEST PLAN

Areas of Concern

Upon receiving a preliminary copy of Accudyne's ECP, the change was reviewed by systems, quality, and electronic engineering personnel at ARDEC. There were several areas of concern for the proposed change:

1. Will the I.C. be able to survive the severe gun-launched environment of the RAAM mine?
2. Is there the possibility of performance degradation of the I.C. due to the long shelf-life requirement of the RAAM mine?
3. Will the I.C. function electronically in the appropriate manner across the temperature spectrum encountered by the RAAM mine?

It was the opinion of the ARDEC engineers that these concerns be addressed by a detailed test plan that verified the I.C. performance at the component, assembly, and system levels.

Qualification Test Plan

The test plan that was drafted by ARDEC engineers addressed the areas of concern listed above the testing the I.C. at the component, assembly, and system levels (app A). Component level testing consisted of initial and end point electrical performance tests at hot, cold, and ambient; various mechanical shock tests that simulate the gun-launched environment of the RAAM mine; thermal shock tests that simulate the temperature spectrum encountered by the RAAM mine; an accelerated aging steady-state life test to determine the shelf-life capacity of the I.C.; a fine and gross seal test to determine the integrity of the hermetic seals of the I.C.; and a series of destructive tests to check the internal configuration of the I.C. upon passing through this series of tests.

The assembly and system level tests were conducted by building RAAM mines with ELAs containing timer and target sensor I.C. with silver-glass die attach. These mines were loaded into 155-mm projectiles and fired at Zone Eight. Firing at Zone Eight deployed the mines approximately 14 kilometers down-range and subjected the mines to a velocity of 2100 ft/s, a maximum pressure of 29,000 lb/in.², a maximum spin rate of 5000 r/min, and a setback force of 8400 G's; that is, 8400 times the acceleration due to gravity (all numbers provided have been rounded for simplicity) (ref 1). These mines were then tested for functioning by means of an applied target signature, AD switch activation (if the mine is so equipped), or SD time-out functioning.

Test Plan Results

Component Level Testing

The component level testing of the silver-glass die attach I.C. was carried out in two stages. The first stage called for initial electrical tests, mechanical and thermal tests, and a final electrical test at Motorola (app A). The results of these tests indicated that the I.C. have a high potential for surviving the mechanical, thermal, and electrical environment of the RAAM mine (refs 2 and 3). There was some concern from ARDEC engineers that the automated test equipment used by Motorola did not preserve the intent of the tests called out in both the qualification test plan and the TDP. However, a meeting was held between ARDEC engineers and engineers from Accudyne and Motorola where it was determined that the tests performed on Motorola's automated equipment were functionally equivalent to those called for by the qualification test plan and the TDP.

The second stage of the component testing called for the I.C. to be dissected and analyzed (app A). No major defects were uncovered during this analysis; however, a condition was discovered that may be a source for possible problems in the future. The internal inspection performed by the Advanced Technologies Laboratory at ARDEC indicates that frit seal material (a glass-like material that is applied between the DIP chassis and the DIP lid during the hermetic seal process) covers the bond pad area (where electrical leads from the transistor die are connected to the external pins of the DIP). This is due to the large physical size of the Motorola transistor die (fig. 8). However, it is the opinion of ARDEC engineers that this frit seal problem is not unique to a silver-glass die attach process. This problem would most likely be inherent with an Motorola I.C., regardless of the die attach process used.

Ballistic Testing

The system and assembly level tests were conducted at Yuma Proving Grounds (YPG) the week of 25 September 1989. This testing consisted of ballistic testing of ten rounds of RAAM M741. The mines used in the ballistic test contained ELA with silver-glass die attach timer I.C. and target sensor I.C. These mines were conditioned hot (+125°F) and fired at Zone Eight.

Of the 90 mines fired ballistically, there were two early SD failures, two sensor failures, two safe duds, and one mine lost (fig. 9). During the subsequent failure analysis of the ELAs, it was determined that the failure mode was physical damage to the circuits from mid-air collisions and ground impact (app B). The cause for physical damage is the high velocity and spinning of the mines during ground impact (fig. 2, physical location of ELA in the RAAM mine assembly). If the mines impact the ground

at an angle, the impact with the ground will cause a large gash to be forced into the ELA, causing physical damage to the electronic components. None of the failures was attributed to inherent electronic failures of either the timer I.C. or the target sensor I.C.

The results of the ballistic testing at YPG were acceptable for approval of the change to silver-glass die attach I.C. The ballistic testing was designed to determine whether the Motorola I.C. would provide 90% reliability at a 95% confidence level. For a new I.C. qualification, one inherent electronic failure is allowed for a total of 77 mines fired ballistically. During this ballistic test, there were zero inherent electronic failures out of 89 mines fired ballistically (one mine was lost during the test). This test confirmed one of ARDEC's major concerns for this change that is, will the silver-glass die attach I.C. survive the gun-launched environment of the RAAM system.

CONCLUSIONS

Silver-glass Die Attach Change for Remote Antiarmor Mine (RAAM)

The testing that was performed to validate the silver-glass die attach engineering change proposal (ECP) submitted by Accudyne indicated that the integrity of the RAAM operating system would not be adversely affected by the integrated circuits (I.C.) change. Also, the fact that Accudyne can procure silver-glass die attach I.C. at a much reduced price than gold eutectic die attach I.C. is an additional benefit to the Government. It is the opinion of ARDEC engineering that the change to silver-glass die attach I.C. is a significant improvement to the RAAM technical data package (TDP).

Other Family of Scatterable Mines (FASCAM) Programs

Due to the commonality of piece-parts in FASCAM systems, this change to silver-glass die attach I.C. has certain ramifications for other mine systems. In particular, approval of the ECP from Accudyne will allow for the use of target sensor I.C. with silver-glass die attach for the M75 GEMSS (Ground Emplaced Mine Scattering System) and for M131 MOPMS (Modular Pack Mine System). ARDEC engineers responsible for these programs reviewed the ECP and determined that the potential change would cause no integrity degradation for the mine systems. This was because RAAM experienced the most extreme physical environment of the three mine systems in question (RAAM, GEMSS, and MOPMS).

Overall Evaluation

Upon reviewing the details of this proposed change, it was observed that such a minor change as die attach material can open up many possibilities for potential problems. In this particular case, there are still some unresolved issues for which an accounting is needed (the frit seal over the bonding pads). However, this change

appears to be promising for the continuation of the RAAM program. Furthermore, changes that will update the TDPs of programs such as RAAM should be encouraged by the Government and given serious consideration whenever presented by contractors.

Table 1. Gold eutectic and silver-glass die attach

<u>Die attach*</u>	<u>Manufacturer</u>	<u>Solution</u>
Gold eutectic	RCA/Harris	26 week lead-time until production unit available
	Honeywell	Cost = approx \$9.00 per I.C.
Silver-glass	Motorola	Approx 6 week lead-time until production units available
		Cost = approx \$3.50 per I.C.

*Timer I.C. (9287165) and target sensor I.C. (9287173).

PROJECTILE, 155MM, AT, M718/741

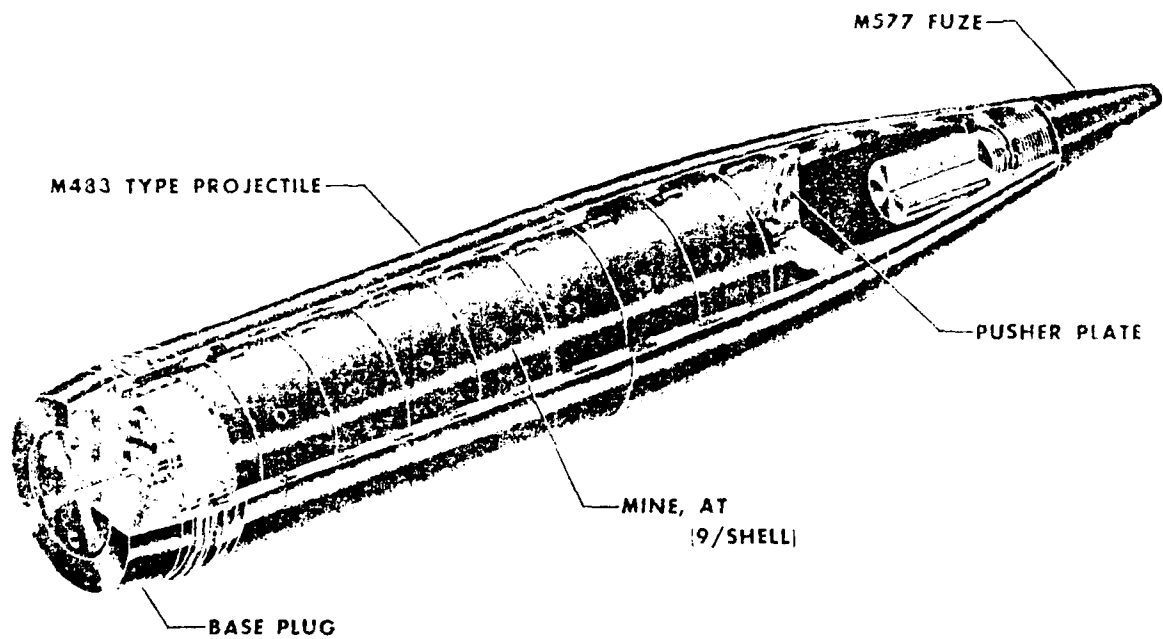


Figure 1. M718/M741 RAAM mine projectile

RAAM MINE

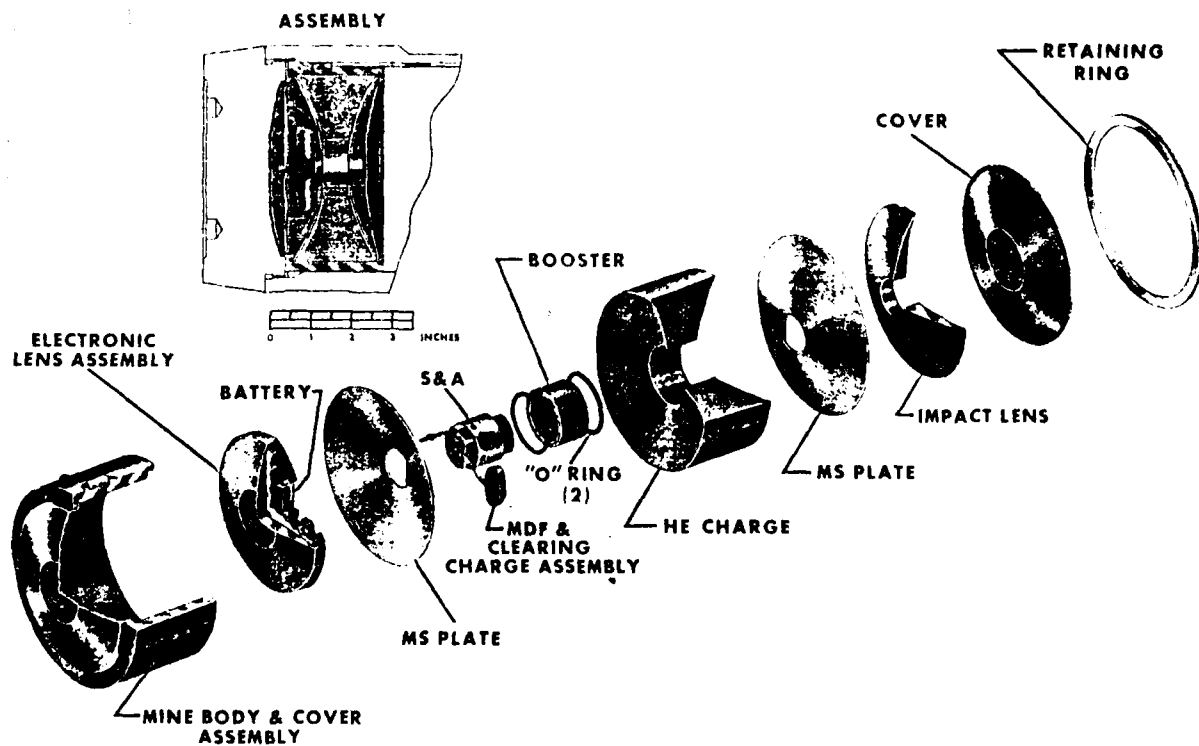


Figure 2. RAAM mine cutaway

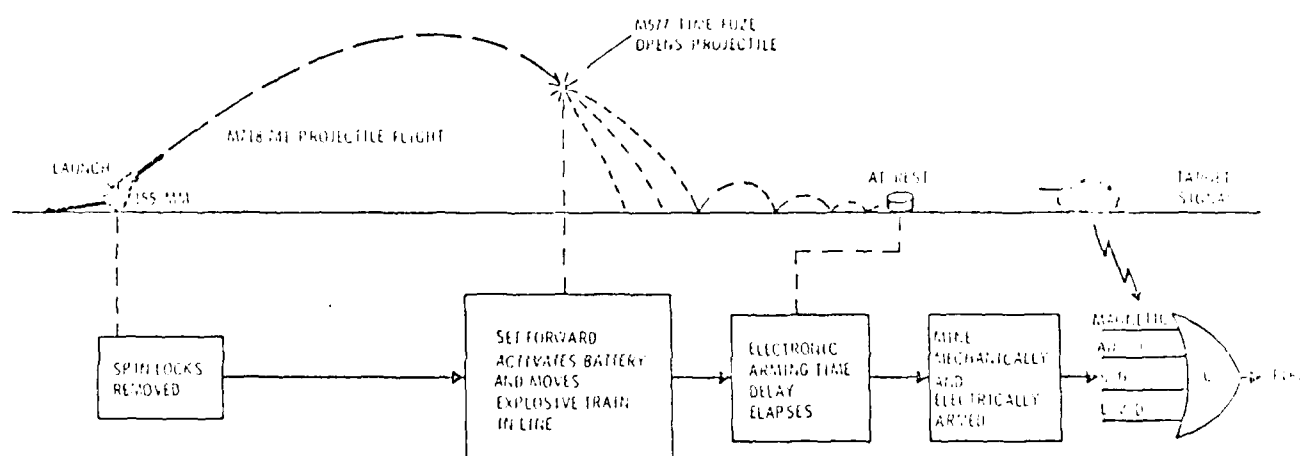
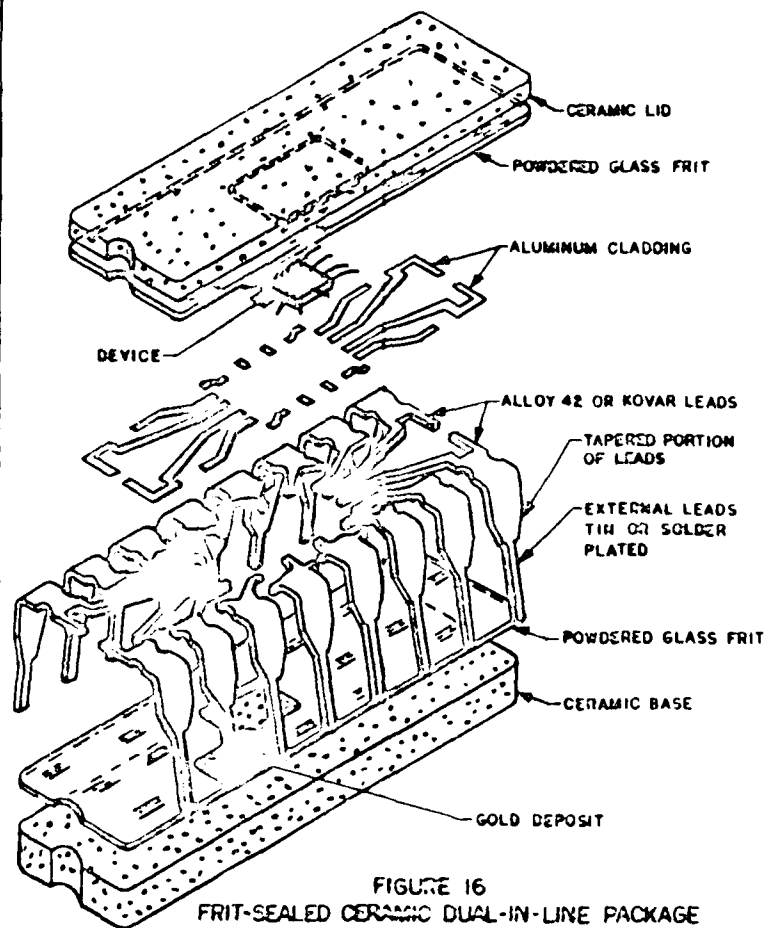


Figure 3. RAAM mine functioning modes

ORIGINAL DESIGN ACTIVITY FSCM NO. 19200



INTEGRATED CIRCUIT TIMING BASE, CMOS	A	FSCM NO. 19200	9287165
01-10-26			

Figure 5. Timer I.C. package cutaway

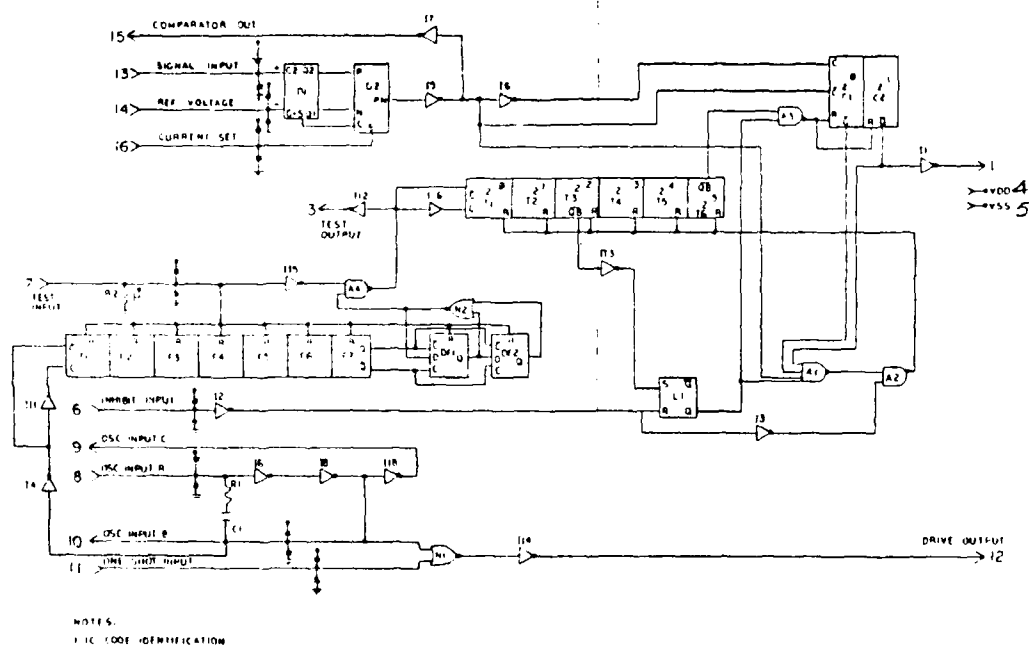


Figure 6. Target sensor I.C. logic diagram

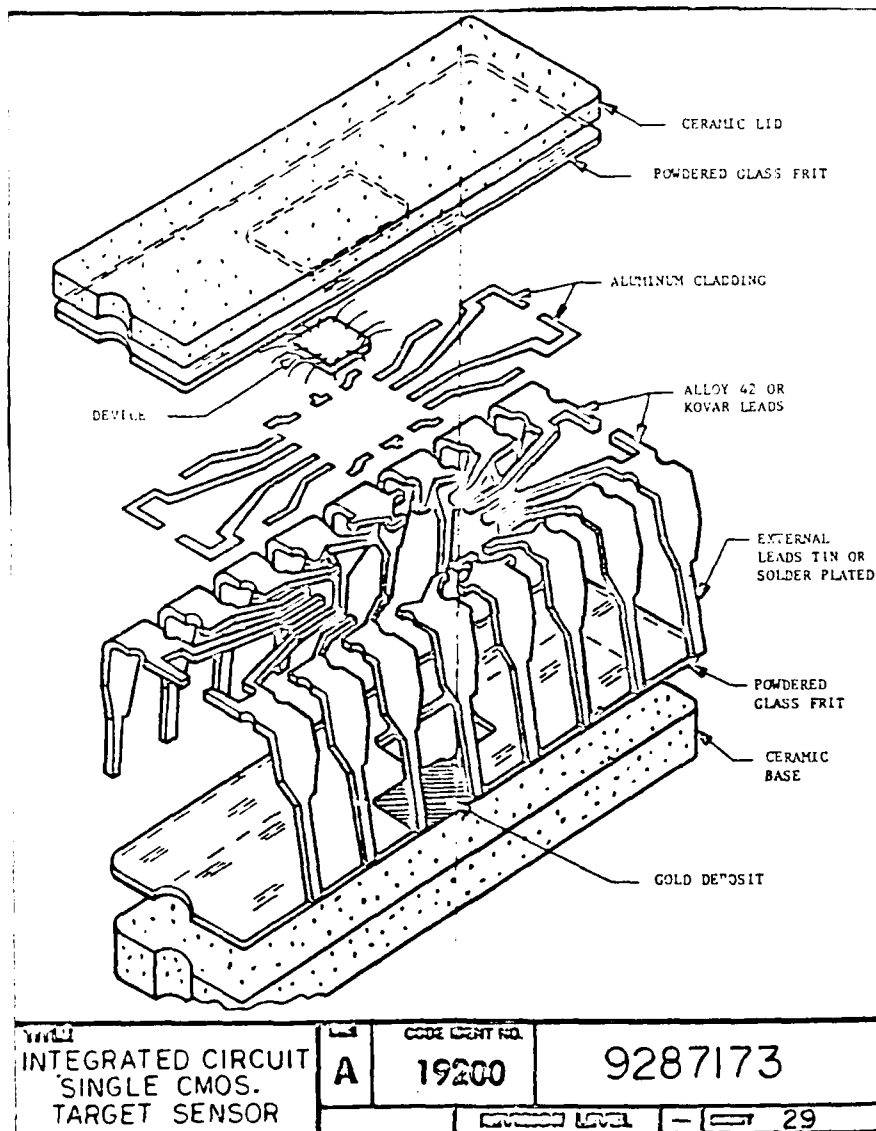


Figure 7. Target sensor I.C. package cutaway

1. RAAM microcircuits, Motorola part number QQ8914 and QQ8913A from Accudyne have been inspected for internal materials, design, and construction per Mil-STD-883 methods 2013, 2014, and 2010.

2. The primary objective was to evaluate the glass/silver die attach used in these devices.

3. The microcircuits meet all construction requirements of Mil-STD-883. Workmanship of the wire bonds and die attach are excellent.

4. While the devices pass all published requirements that we are familiar with, package design concerns us. The I.C. die is large, so a large cavity is required. The sides of the cavity are so narrow that the frit seal must be made over the bonding pads. This results in the wire bonds being embedded in the frit. (See Fig. 1)

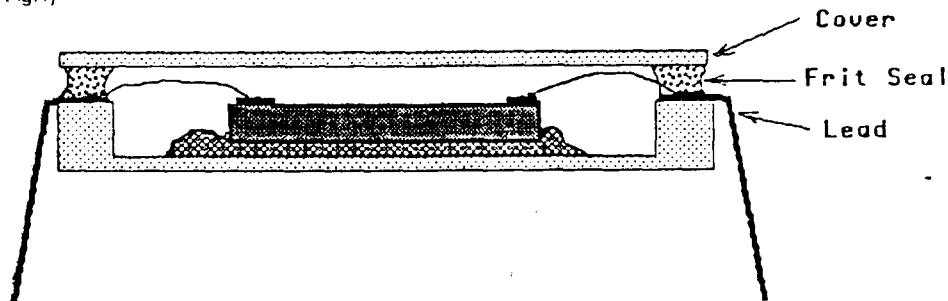


Fig. 1 Wires embedded in frit used to seal lid to I.C. package.

5. There is reason to be concerned if the frit flows over the bond wires during sealing, due to the increased risk of mechanical stresses, or corrosion. In this case, there is also the possibility of damage to the wires during application of the frit, and lid.

6. RECOMMENDATIONS: While the microcircuits meet the requirements of Mil-STD-883 and should be accepted, it would be advisable to discuss the package design with the manufacturer, and attempt to eliminate the embedded wires.

Figure 8. Advanced technologies laboratory memorandum

Type Test First Firing Projectile lot No. 10P89J0025942
 Test lot No. ACC89G001A001 Date Fired: 26 Sept. 89 SA# 1 To 5
 Firing: Charge MW9A2 Zone: 7R All Component Temp. 145
 Test equipment used: Simpson Model 200-2 Digital Volt-Ohm-Milliammeter
 Calibration Date: 2 Oct. 88 Due for Calibration 21 Oct. 89
 All readings taken with cable assembly disconnected from lens.
 S&A Device Lot No. AKT88G504-011
 Primer, STab Lot No. L5-86A368-019

Proj No.	Mine No.	Mine Attitude Degrees	Lens Func.	S&A Slider in line	Battery Voltage Cell			Short-circuit Bar	S&A Ohms	Lens Ser. No.
					No. 1	No. 2	Total			
633	✓ 1	1-1	0		SD	OK				SD
531	✓ 1-2	0			SD	OK				
	✓ 1-3	0	X	X	3.38	3.38	6.75	OPEN	3.0	
	✓ 1-4	0			SD	OK				
	✓ 1-5	0	X	X	-1.62	2.34	0.62	OPEN	2.6	Battery?
311	✓ 1-6	0			SD	OK				
528	* 1-7			Found a dia	SD	Time				Missing
30	* 1-8	0			SD	OK				
401	✓ 1-9	0			SD	OK				SD
Firing: QE 396 HOB 218 HOB Expected 249 HOB Difference -31										
47	✓ 2-10	0			SD	OK				SD
48	✓ 2-11	0		Found a dia	SD	Time				Missing
309	✓ 2-12	0			SD	OK				
645	✓ 2-13				SD	OK				
56	✓ 2-14				SD	OK				
631	✓ 2-15				SD	OK				
206	✓ 2-16				SD	OK				
9	✓ 2-17				SD	OK				SD
	✓ 2-18	0			SD	OK				
Firing: QE 398 HOB 293 HOB Expected 249 HOB Difference +44										
320	✓ 3-19	0			SD	OK				SD
26	* 3-20	0			SD	OK				
34	✓ 3-21			WAS NOT FOUND						Missing
415	✓ 3-22	0			SD	OK				Possible
341	✓ 3-23				SD	OK				
308	✓ 3-24				SD	OK				
322	✓ 3-25				SD	OK				
413	✓ 3-26				SD	OK				SD
	✓ 3-27	0			SD	OK				
Firing: QE 378 HOB 336 HOB Expected 249 HOB Difference +87										
645	* 4-28	0		All mine	2	SD	OK			SD
314	✓ 4-29	50								Buried
40	✓ 4-30	0								
45	✓ 4-31	45								Buried
	✓ 4-32	0								
6	✓ 4-33	0								
	✓ 4-34	0								
407	✓ 4-35	0								SD
414	✓ 4-36	0								AND A
Firing: QE 389 HOB 251 HOB Expected 245 HOB Difference +6										
57	* 4-37									

LEGEND: HOB - Height of Burst obtained
 HOB Expected - Height of Burst above ground level as per firing table
 FT 155 ADD-II-1
 Height of Burst (meters) = 50 + .5 (QE) where QE is in mils
 QE - Quadrant Elevation (Weapon elevation angle in mils)
 X - Yes
 * - INTERMINE COLLISION DAMAGE

Figure 9. Yuma Proving Grounds, (YPG) ballistic scoring sheets

Type Test: Accuracy Projectile lot No. 10089J0025942
 Test lot No. ACC89G001A001 Date Fired: 27 Sept 89 SA# 6 To 10
 Firing: Charge M19A2 Zone: 7R All Component Temp. 145
 Test equipment used: Simpson Model 360-2 Digital Volt-Ohm-Milliammeter
 Calibration Date: 20 Oct 88 Due for Calibration 21 Oct 89
 All readings taken with cable assembly disconnected from lens.
 S&A Device Lot No. AKT88G504-011
 Primer, S&A Lot No. LS-86A368-019

Accuracy SR#	Proj SA, No.	Mine No.	Atti- tude Degrees	Lens Primer Func	S&A Slidder in line	Battery Voltage Cell No. 1 No. 2 Total	Short- ing Bar Ohms	S&A Ohms	Lens Sec. No.
						+8-3 +3-9 +8-9	+E3-9	+E1-E2	
51	✓ 5	5-37	0		ALL OTHER	Mines Sensor	IND AD OK		Sensor
649	* 5	5-38	0						And A
27	✓	5-39	45						Buried
50	✓	5-40	0						
49	✓	5-41	0						
Possible Target Sensor	5-42	0		X	X	X	2.01 1.98 3.96	OPEN	Fired
55A	✓	5-43	0						Sensor
Possible Target of Area	5-44	5		X	X	X	2.05 2.01 4.02	OPEN	Fired
21	✓	5-45	0						And B
Firing: QE 389 HOB 205 HOB Expected 245 HOB Difference -40									
630	✓ 6	6-46	0		SD OK				SD
83	✓	6-47	0		SD OK				
Function Sensor	6-48	0		X	X		3.25 3.25 6.47	OPEN	Fired Early
53A	✓	6-49	0		SD OK				
79	✓	6-50	0		SD OK				
105	✓	6-51	0		SD OK				
622	✓	6-52	0		SD OK				
15	✓	6-53	0		SD OK				
513	✓	6-54	0		SD OK				SD
Firing: QE 402 HOB 353 HOB Expected 251 HOB Difference +101									
2	✓ 7	7-55	0		SD OK				SD
619	✓	7-56	0		SD OK				
635	✓	7-57	0		SD OK				
82	✓	7-58	0		SD OK				
5	✓	7-59	0		SD OK				
66	✓	7-60	0		SD OK				
31	✓	7-61	50		SD OK				
25A	* 7	7-62	0		SD OK				
41	✓	7-63	0		Functioned while carrying to center location				SD
Firing: QE 394 HOB 366 HOB Expected 247 HOB Difference +117									
615	✓ 8	8-64	45		ALL OTHER	Mines Sensor	IND AD OK		Buried
728	✓	8-65	0						
77	✓	8-66	45						Buried
328	✓	8-67	10						
24	✓	8-68	0						
628	* 8	8-69	45						Buried
7	✓	8-70	45						Surface
EARLY	8-71	0		X	X		3.38 3.38 6.77	OPEN	Fired Early
315	✓	8-72	45						Buried
Firing: QE 386 HOB 239 HOB Expected 243 HOB Difference -4									

LEGEND:

HOB - Height of Burst obtained
 HOB Expected - Height of Burst above ground level as per firing table
 FT 155 ADD-N-1
 Height of Burst (meters) = 50 + .5 (QE) where QE is in
 mils

QE - Quadrant Elevation (Weapon elevation angle in mils)
 X - Yes

* INTERMINE COLLISION DAMAGE

(5-70 339)
 ?

Figure 9. (cont)

Short-

LEGEND:

- HOB - Height of Burst obtained
- HOB Expected - Height of Burst above ground level as per firing table
FT 155 ADD-N-1
Height of Burst (meters) = $50 + .5 (QE)$ where QE is in mils
- QE - Quadrant Elevation (Weapon elevation angle in mils)
- X - Yes
- * - INTERMINE COLLISION DAMAGE

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GLOSSARY

AD	Anitdisturbance
CMOS	Complimentary metal oxide semi-conductor
DIP	Dual in-line package
ECP	Engineering Change Proposal
ELA	Electronic lens assembly
FASCAM	Family of scatterable mines
GEMSS	Ground Emplaced Mine Scattering System
IC	Integrated circuits
IAAP	Iowa Ammunition Assembly Plant
LVD	Low voltage detect
MOPMS	Modular Pack Mine System
PTB	Primary time base
PWB	Printed wiring board
RAAM	Remote Anti-Armor Mine
SD	Self-destruct
TDP	Technical data package
TTB	Test time base
VECP	Value engineering change proposal
YPG	Yuma Proving Ground

APPENDIX A

RAAM QUALIFICATION TEST PLAN FOR SILVER GLASS
DIE ATTACH IN MICROCIRCUITS

1. Microcircuits shall be serialized.

2. All parts shall be verified for electrical performance characteristics in accordance with the appropriate drawing. Testing shall be performed at hot, cold, and ambient temperatures.

3. Ballistic Firing:

a) Accudyne shall test microcircuits according to the test plan for integrated circuits in Drawing #9317646.

b) Half of the mines recovered from ballistic firing of the lenses containing the above microcircuits will be tested for magnetic target functioning. The remaining half of the recovered mines will be tested for Self-Destruct functioning. In accordance with the requirements of Drawing #9317646, results of these functioning tests shall determine whether the test microcircuits are qualified. All failures will be analyzed to determine the reason for failure.

c) The test lenses will be furnished to ARDEC for internal visual inspection for destructive physical analysis (DPA) of the integrated circuit per MIL-STD-883, Method 2013.

4. Fifteen parts which have passed the tests in 2 above shall be subjected to the following tests in the order shown:

a) Thermal shock shall be performed in accordance with MIL-STD-883, Method 1011, Test Condition B.

b) Mechanical Shock shall be performed in accordance with MIL-STD-883, Method 2002, Test Condition G. Test shall consist of five (5) shocks, 3 shocks in the Y1 direction and 2 shocks in the Y2 direction.

c) Vibration, variable frequency shall be performed in accordance with MIL-STD-883, Method 2007, Test Condition A.

d) Steady state life accelerated aging shall be performed at 150°C for a period of 177 hours. At the conclusion of the temperature exposure, the parts will be returned to ambient temperature.

e) External Visual shall be performed in accordance with MIL-STD-883, Method 2009. Parts shall meet the requirements of the part drawing.

f) Constant acceleration testing shall be performed in the Y1 direction at 35 KG.

g) Seal tests shall be performed in accordance with MIL-STD-883, Method 1014, Test Conditions A (Fine Leak) and C (Gross Leak).

h) End point electrical verifications shall be in accordance with the performance requirements of the part drawing. Testing shall be performed at hot, cold, and ambient. Measurements shall be data logged.

5. Five (5) microcircuit parts which have passed 4h above shall be subjected to internal visual inspection for destructive physical analysis (DPA) in accordance with MIL-STD-883, Method 2013. Photographs shall be taken as required to document failures or anomalies.

6. a) Five (5) microcircuits from 4h above shall be reserved for water vapor testing. Three microcircuits - at least one (1) timer and one (1) target sensor - shall be subjected to the internal vapor analysis in accordance with MIL-STD-883, Method 1018. The maximum allowable water vapor is 5000 ppm by volume (AC-0). If only one of three samples fails and it has a water vapor content of less than 8000 ppm, two additional units shall be tested for the 5000 ppm limit. If both additional units pass the test, the lot passes the internal water vapor test. Only one of the five samples may exceed 5000 ppm water vapor, and it must not exceed 8000 ppm.

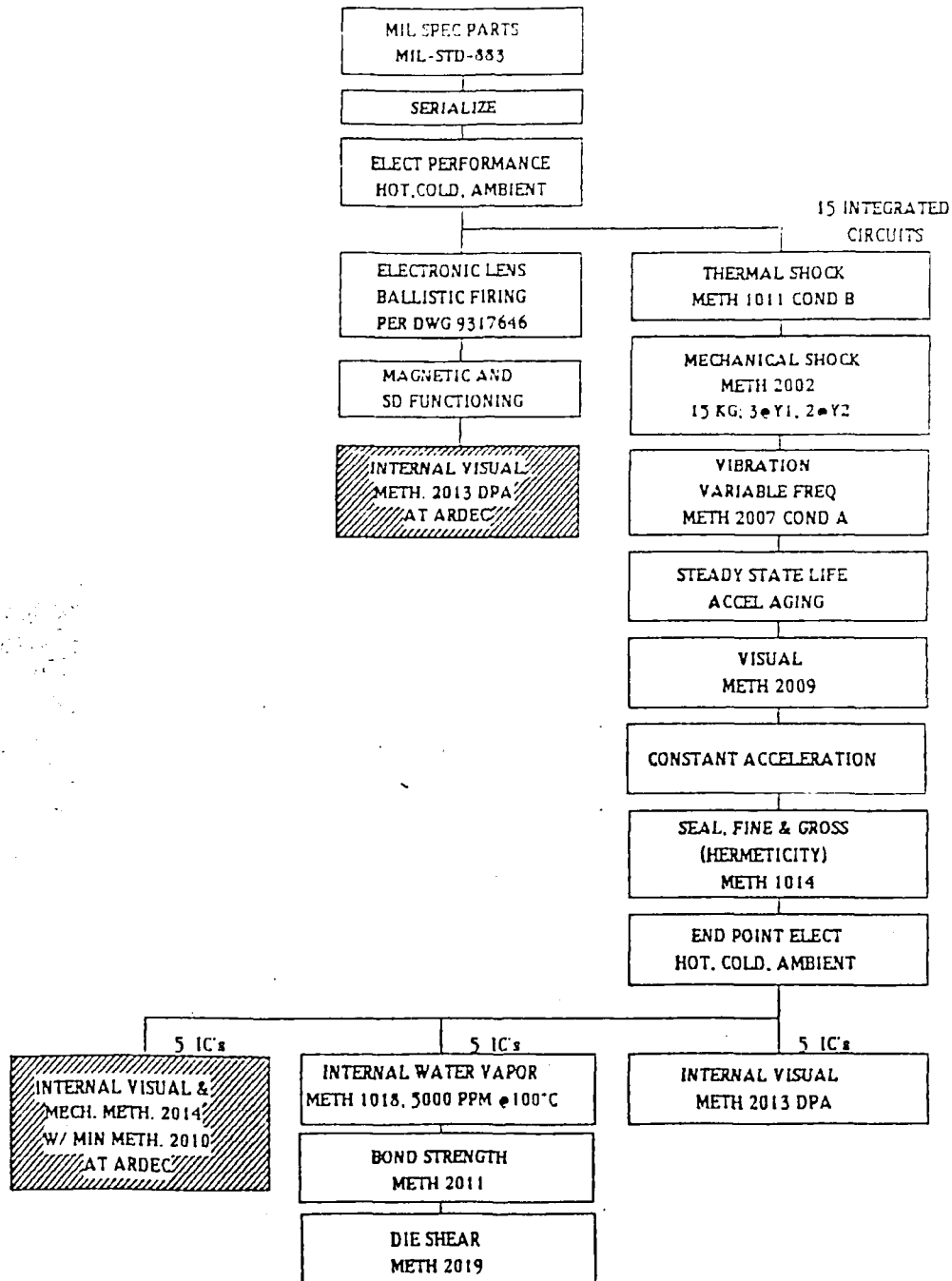
b) The five (5) microcircuits from 6a above shall have all bond wires subjected to a bond strength test in accordance with MIL-STD-883, Method 2011, Test Condition C.

c) The five (5) microcircuits from 6b above shall be subjected to a die shear strength test in accordance with MIL-STD-883, Method 2019. The measurement results shall be data logged.

7. The remaining five (5) microcircuit parts from 4h above shall be furnished to ARDEC to be subjected to internal visual and mechanical verification in accordance with MIL-STD-883, Method 2014. Photographs will be taken to document the overall die layout (typical) and to document any anomalies found during examination.

8. Failure analysis shall be performed on failed parts to establish failure modes and will be used to determine the feasibility of supplier corrective action that will ultimately result in a qualified part.

9. A qualification test report shall be written at the completion of the testing.



APPENDIX B
TRIP REPORT

TRIP REPORT

DISCUSSION AND DETAILS OF VISIT:

On the evening of the 25th of September, we met with Pete Calik (YFG Proof Director) to plan for RAAM firings in the morning. In the morning we were at the firing range by dawn and started firing by a few minutes past 7:00. The first test round landed somewhat past the preferred impact zone and we had difficulty in locating all of the mines. Some corrections were made but the second round also landed too far out. Consequently, there were 7 mines that we could not locate. The next 3 rounds were good. By the end of the day we had located all but 3 mines (we found 4 of the lost 7). We had 2 duds and 2 sensor failures (these 2 later did fire by SD).

The next day we fired the other 5 rounds. We located not only all of the mines from those rounds, but also found 2 of the 3 mines lost from the day before. These 2 rounds had functioned.

There were 2 early functions in the last 5 rounds. By the time we located them, they had functioned.

All failure mines were torn down and checked for S&A function, MDF burn, and ELA electronic and physical condition. The 2 duds had non-functioned S&A's, and damage to the lens covers. The 2 sensor failures and the 2 earlies had damage to the lens covers and the S&A's had functioned. The damage on the lens covers was attributed to mid-air intermine collisions.

Finally, all functioned mines were torn down for S&A, MDF and ELA inspection. All of these results are in the enclosed data sheets made by Peter Calik and added to by Steve Herbst and me.

RECOMMENDATION:

The six lenses should be analyzed by Accudyne to determine whether the possible cracked IC's were the cause of the mine failures. According to the test plan, only one failure may be traced to the Silver-Glass die attached process or the IC's will fail the qualification test.

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